Synopsis proposal for Ph.D. programme

Numerical study of entropy generation and heat transfer of nanofluid over a stretching sheet

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Recent years, researcher have shown much interest in the varieties of problems related to boundary layer flow and heat transfer of Newtonian and non-Newtonian fluids. The reason for such excellent interest is due to their applications in the boundary layer flows in many science and engineering areas, for instance, in wire and blade coating, movement of biological fluids, plastic manufacturing, food processing etc. The mathematical model of the boundary layer flow system is well described by a set of nonlinear partial differential equation (PDE), those can not be solved exactly. Also, non-Newtonian fluid rheology has attracted many researcher to carry out research work in many areas of convective heat transfer during the past few decades. In this case, Navier-Stoke's equations can not effectively describe the flow of non-Newtonian fluids. Also, such fluids can not be analysed by a single constitutive relationship between shear stress and rate of strain. Due to this reason several methods of such fluids have been described in the literature. In recent time, many research scholars have studied the entropy generation and fluid flow and heat transfer over a stretching sheet by considering Newtonian and non-Newtonian fluids. The interaction of buoyancy force with thermal radiation has also increased greatly during the last decade due to its importance in many practical applications under many different physical situations of thermal boundary conditions such as isothermal and non-isothermal. Such types of studies are important if the entire system involved the polymer extrusion processes is placed in a thermally controlled environment, then in this situation the influence of thermal radiation can not be neglected. Hence, the knowledge of thermal radiation convective heat transfer in the system can lead desired product with a required characteristics. Also, the thermal radiation effect in convective flow and heat transfer are important in the context of space technology and in the processes involving high temperature.

The literature review shows that there have been many work previously carried out on magnetohydrodynamics (MHD) flow and heat transfer processes those occurred in many applications such as cooling of nuclear reactors, geothermal system, heat exchanger design and aero dynamic processes. Thus the problem of pre-convection under the influence of magnetic field has attracted the interest of many researcher to study the combined effects of magnetic field and thermal radiation in various type of boundary layer flows by considering Newtonian and non-Newtonian fluids.

By going through the literature, it has been found that not much work has been done in the above types of flow for entropy generation. The emerging area of research in entropy generation is due to thermo-diffusion (Soret effect) and diffusion-thermo (Dufour effect). Thermal diffusion, so called solutal thermo-diffusion which corresponds to species differentiations occurring in an initially homogeneous mixture submitted to a thermal gradient, whereas diffusion-thermo are Dufour effect corresponds to the energy flux caused by concentration gradient in a binary fluid or mixture. In many previous studies, Soret and Dufour effects were neglected in the boundary layer flows on the basis that they are of smaller order of magnitude than the effects described by Fourier's and Fick's laws.

In recent times, there seems to be a major shift from traditional way of heat transfer enhancement to modern mechanism of suitable dispersion and sustainable suspension of nanoparticles of higher thermal conductivity such as metals, oxides, carbides, nitrites particles of 100nm or less

size in conventional fluids of lower thermal conductivity such as, ethyl glycol, tri ethyl glycol, engine oil, in order to give high heat transfer capability nanofluids. Renowned scientist Choi[1] has pioneered experimentally to impart such contribution to the researcher to work on many areas by considering nanofluids to meet the modern cooling requirements in industrial manufacturing processes. Major application of nanofluids as coolants are in cancer therapy, safer surgery, heat exchangers, micro-channel heat sink and several electronics devices, in designing the waste heat removal equipment, polymer extrusion, glass blowing, cooling of micro electronics and many others.

The studies of magneto-nanofluids boundary layer flow and heat transfer find applications in many areas which includes gastric medication and great importance in processes such as targeted release, asthma treatment, magnetic cell separation, magnetic resonance imaging, elimination of tumers with hyperthermia, etc. The non-Newtonian fluids are more important in technological applications in comparison with Newtonian fluids. A large class of real fluids does not exhibit linear relationship between stress and rate of strain. There are many non-Newtonian fluids such as micropolar fluid, viscoelastic fluid, power-law fluid, second grade fluid, Casson fluid, and Jeffrey fluid to which nano-particles can be added to make them non-Newtonian nanofluids. Not much research work has been done in entropy generation and heat transfer by considering Newtonian nanofluid and non-Newtonian nanofluid to analyze the combined effects of magnetic field, nonlinear thermal radiation, viscous dissipation and Ohmic dissipation in the boundary layer flows over a stretching sheet.

Literature survey indicates that tremendous interest has grown up among researchers in the investigation of behavior of Newtonian and non-Newtonian nanofluids flows in different geometries and applications in last few decades. Hayat et al. [2] constructed the series solution to the nonlinear problem by powerful analytic approach namely the Homotopy analysis method (HAM) for MHD flow of Jeffery fluid in porous channel. Motsa [3] analyzed a new spectral local linearization method for nonlinear boundary layer flow problems. Domairry et al. [4] studied natural convection of a non-Newtonian copper-water nanofluid between two infinite parallel vertical flat plates. They solve analytically the governing differential equation using differential transformation method (DTM) and observe that when nanoparticles volume fraction increases, the momentum boundary layer thickness increases but the thermal boundary layer thickness decreases. Aiboud and Saouli [5] analysed entropy generation in viscoelastic MHD flow over a stretching surface. Noghrehabadi et al. [6] analysis entropy generation of a nanofluid flow over a stretching sheet with heat generation or absorption. Butt et al. [7] studied the effects of velocity slip on entropy generation over a vertical sheet with convective boundary condition in the boundary layer flow. Bejan [8,9] studied different reasons behind entropy generation in applied thermal engineering. Abolbashari et al. [10] studies the Homotopy analysis method (HAM) for entropy generation in an unsteady MHD nanofluuid flow adjacent to a stretching surface with water as the base fluid and different types of nanoparticles. Qing et al. [11] discussed the entropy generation on magnetohydrodynamic flow of Casson fluid in porous stretching or shrinking sheet. Hakeem et al. [12] analyzed the effect of slip on MHD flow and heat transfer of Newtonian or non-Newtonian fluid in the presence of magnetic /non-magnetic particles. Nayek [13] investigated the effect of viscous dissipation on flow of nanofluids in the presence of transverse magnetic field in a porous medium with thermal radiation. Weigand and Birkefeld [14] focused on entropy generation due to laminar flow over a flat plate. Makinde [15] discussed a second law analysis for the hydromagnetic boundary layer flow and heat transfer over a stretching sheet in the presence of thermal radiation. Nayek [16] has discussed in his study that the thermal radiation should be considered minimum

so as to achieve more cooling due to MHD viscoelastic fluid flow over a stretching sheet. Baag et al. [17] studied the entropy generation analysis for viscoelastic MHD flow over a stretching sheet embedded in a porous medium. Navid and Asghar [18] discussed the exact solution of entropy generation for MHD nanofluid flow induced by a stretching/shrinking sheet with transpiration. Janardhana Reddy et al. [19] analysed that the collidal study of magnetohydrodynamic couple stress fluid flow over an isothermal vertical flat plate with entropy heat generation. Malvandi et al. [20] studied analytically the steady two-dimensional boundary layer flow over an isothermal flat plate by homotopy perturbation method (HPM) and discussed the entropy generation inside the boundary layer.

In order to solve the governing equations for the suggested problems it is first required to transfer the nonlinear partial differential equation (PDE) to nonlinear ordinary differential equation (ODE) by using the similarity transformation, since the governing equations are highly nonlinear and the analytical solution are difficult to obtain. Thus we resort to the numerical technique in order to solve the transformed nonlinear ordinary differential equations. During my Ph.D work, I intend to develop a numerical technique by using Spectral Quasilinearization Method. There are other numerical methods and semi-analytical methods such as Runge-Kutta-Felbherg method, Homotopy Analysis Method (HAM), Homotopy Perturbation Method (HPM), Differential Transform method (DTM) by which the governing transformed nonlinear differential equations can easily be solved. But the spectral quasilinearization method is the best among the various numerical and semi-analytical methods.

Thus, in the proposed Ph.D work, I want to devote myself to the following problems using Spectral Quasilinearization Method and Runge-Kutta-Felbherg method :

1. Entropy analysis for MHD flow and heat transfer of a Jeffrey nanofluid over a stretching sheet in the presence of nonlinear thermal radiation ;
2. Combined effects of viscous dissipation and Ohmic dissipation for the entropy generation in thermal convective flow and heat transfer over a stretching sheet;
3. Entropy generation and heat transfer of a viscoelastic nanofluid over a stretching sheet in the presence of nonlinear thermal radiation and Soret effect;
4. Entropy generation for convective flow and heat transfer over a stretching sheet with nonlinear thermal radiation in the presence of Soret-Dufour effects under convective boundary condition;
5. Entropy generation and heat transfer over a stretching sheet in Casson nanofluid in the presence of nonlinear thermal radiation and Navier slip effect;
6. Effect of non-uniform heat source sink and heat transfer over a stretching sheet in a porous medium in the presence of Soret-Dufour effects;
7. Effect of magnetic field and nonlinear thermal radiation on entropy generation analysis over a stretching sheet in micropolar nanofluid.

The above proposed work would be interesting and important in the field of industries and manufacturing processes. We hope the result would be very useful and taking the computed results one can improve the manufacturing processes in industries.

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